Measuring the Effect of Radio Frequency Identification Technology (RFID) on Movement of US Army Resupply Cargo

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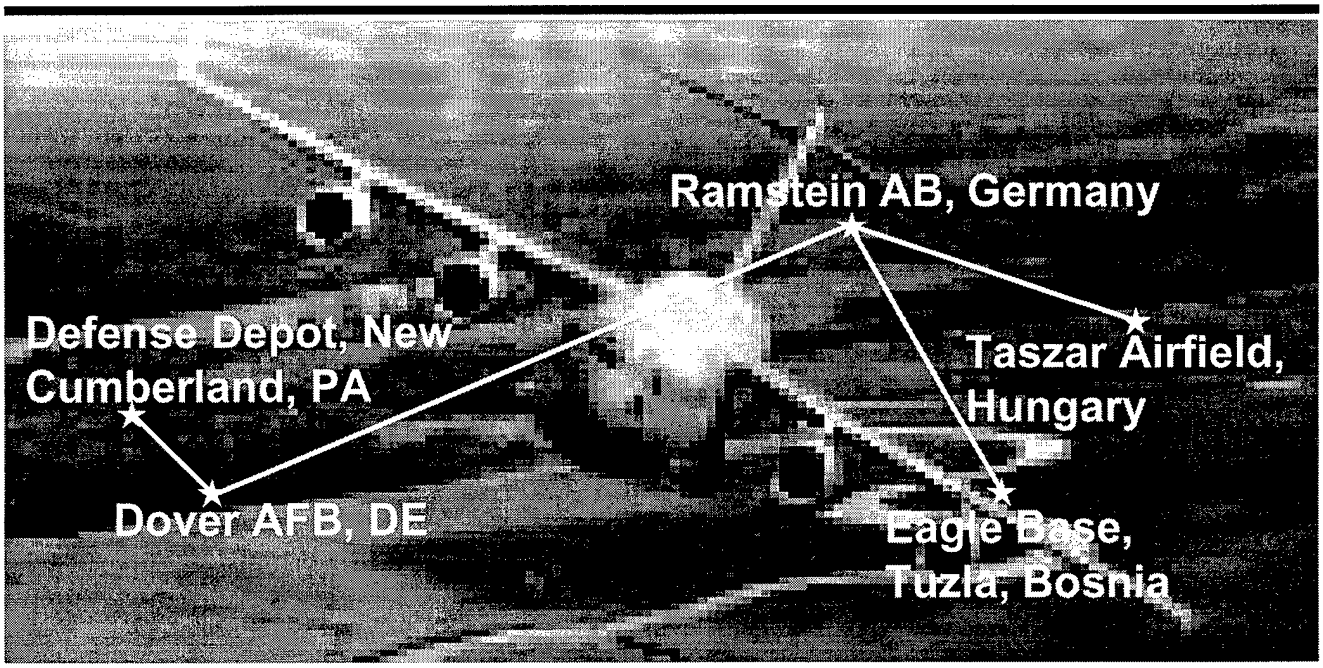

Figure 1. Routing of Army RFID-tagged Resupply Cargo Shipments

Introduction

From the moment a military unit places a requisition for parts or supplies into the supply system, two things about the shipment—the status and expected arrival date—are of interest to the end-user. With the proliferation of computers, information systems, the Internet and information technology applications such as bar code readers, the visibility of this information is now possible. A powerful way for customers to gain logistics information about their requisitions currently exists on the World Wide Web (WWW)—the Global Transportation Network (GTN). Now an end-user of an expected part or resupply item, located in an austere environment with only a laptop, can *uplink* or connect with an orbiting satellite and log-on to the Internet and the GTN web site. Once connected, the GTN web site provides detailed status and movement information as a shipment moves through the Defense Transportation System (DTS). This is the idea of in-transit visibility (ITV)—visibility of an item, person or unit en route from origin to destination during peace, contingencies and war.[1]

The US Army is moving cargo through the DTS[2] from the Defense Depot at New Cumberland, Pennsylvania, to the Bosnia-Herzegovina theater of operations using Radio Frequency Identification (RFID) technology. RFID technology involves a series of electronic tags (attached to the desired item and containing shipping/content information), interrogators (located at key nodes along the route of travel) and a computer-based system to collect the movement information. Shipping information is recorded on the tag at the shipment's origin and may be read by stationary or handheld interrogators using radio frequency energy to activate the tags and transmit information. Once identified by an interrogator, a date and time stamp is recorded and uploaded to an Internet server and a hosted web site where it is added to previously collected information.

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The purpose of this research was to investigate the Army's use of Internet-based RFID technology for ITV and determine whether there is a difference in cycle time for resources moving through the Air Mobility Command (AMC)[3] portion of the DTS. The goal was to evaluate the contribution that Internet-based visibility of high-priority cargo associated with the application of RFID technology can make to total cycle time relative to non-RFID-tagged cargo. The hypothesis of this research was that the visibility of *tagged* items speeds the flow of resources in comparison to *non-tagged* items as they move through the AMC system—from the aerial port of embarkation (APOE) to the aerial port of debarkation (APOD).

Background

Although the implementation of various Information Technology (IT) applications is known to contribute to ITV, there has been no attempt to quantify the contribution these technologies make in terms of shipment cycle time between the requisition source and the end-user.

In-transit visibility (ITV) is defined by USTRANSCOM as the "ability to track the identity, status, and location of . . . cargo and passengers . . . from origin to the consignee or destination . . . during peace, contingencies, and war."[4] ITV of resupply (sustainment) materiel for forward-operating units is one of the most frustrating problems for logisticians in the field. A significant problem logisticians had to wrestle with during DESERT SHIELD/DESERT STORM (DS/DS) was the inability to effectively deal with the arrival of thousands of shipping containers with little or no idea about what was in them. In fact, during DS/DS, of the 40,000 containers of military materiel entering the theater, approximately 50 percent of them had to be opened, inventoried and reinserted into the transportation system because military personnel did not know their contents.[5] The Center for Army Lessons Learned cited three main reasons for these accountability and visibility problems. Specifically, containers packed at US depots lacked an adequate description of container contents, they arrived in Southwest Asia faster than the logistics system could process them and there were no procedures to document arriving containers designated for specific units.[6]

A recent General Accounting Office (GAO) report was critical of the federal government's inability to "properly account for and report billions of dollars of property, equipment, materials, and supplies."[7] The report noted that "certain recorded military property had, in fact, been sold or disposed of in prior years—or could not be located—and an estimated $9B of known military operating materiel and supplies were not reported."[8] The report also criticized the Pentagon for being uncertain about how much inventory was in-transit and the government's ability to "prevent unnecessary storage and maintenance costs or purchase of assets already on hand."[9]

Recently, the DoD, through United States Army Europe (USAREUR) developed a transportation pipeline that uses RFID technology to track supplies from the Defense Depot, New Cumberland, Pennsylvania, to Taszar, Hungary, and Tuzla, Bosnia, in support of OPERATION JOINT ENDEAVOR (OJE)[10] and OPERATION JOINT GUARD (OJG) (see Figure 1). These containerized or palletized shipments are tracked by attaching RFID tags to the cargo. These tags provide information to a system of interrogators stationed along the route of travel that transmit information through a portable control system into a database. Individual users are able to query this system via an Internet web site.

Although the implementation of various Information Technology (IT) applications is known to contribute to ITV, there has been no attempt to quantify the contribution these technologies make in terms of shipment cycle time between the requisition source and the end-user. Since there is some perception in the DoD that "ongoing transportation initiatives, such as ITV, will [result in] . . . reducing logistics response time by improving transit times,"[11] this study was aimed at comparing the movement of a set of RFID-tagged shipments to a set of non-RFID-tagged shipments as well as a set of DoD standards in an attempt to examine RFID technology's contribution to ITV and cycle time.

Total Asset Visibility (TAV) and In-Transit Visibility (ITV)

During DS/DS, units awaiting supplies had only a limited ability to trace their shipments. Concluding this situation was unacceptable, the DoD developed a *Total Asset Visibility Plan* that identified three categories of assets: in-storage, in-transit and in-process. Visibility over the status and location of these assets is known as Total Asset Visibility (TAV). The advent of Army Total Asset Visibility (ATAV) and, subsequently, Joint Total Asset Visibility (JTAV), provided a forum for testing emerging technologies such as RFID.

The DoD defines TAV as:

> . . . the capability that permits operational and logistics managers to determine and act on timely and accurate information about the location, quantity, condition, movement and status of Defense material. It includes assets that are in-storage, in-process and in-transit.[12]

Several significant DoD publications have highlighted the need for effective ITV. *Joint Vision 2010*, a conceptual template for the development of the US Armed Forces, discusses four new operational concepts: dominant maneuver, precision engagement, full dimensional protection and focused logistics.[13] In order to optimize the first three concepts, focused logistics must integrate

> . . . information, logistics, and transportation technologies to provide rapid crisis response, to track and shift assets even while en route, and to deliver tailored logistics packages and sustainment directly at the strategic, operational, and tactical level of operations.[14]

The 1998 Air Mobility Master Plan (AMMP) considered achieving ITV the "single most challenging task" for USTRANSCOM[15] and one of AMC's top five modernization priorities.[16]

In the 1996 Annual Report to the President and the Congress, the Office of the Secretary of Defense (OSD) identified "visibility of material in storage and transit and rapidly transporting stocks between theaters" as essential to the National Security Strategy of winning "two nearly simultaneous major regional conflicts."[17] Furthermore, TAV would enable managers to "offset wholesale procurements with excess retail assets . . . increase user confidence, reduce duplicate requisitions, and expose supply and transportation system bottlenecks."[18] The 1998 DoD Logistics Strategic Plan reiterates this through the objective of "full fielding of identified TAV capabilities"—targeting 90 percent implementation by February 2000 with 100 percent capability by February 2004.[19]

The Internet and Information Technology

The private-sector logistics industry has always been very competitive and the use of the Internet for IT applications is a way many companies in the commercial sector are competing. Deregulation of the transportation industry in the 1970s and 1980s opened up commercial industry for investment in emerging technologies as a way to achieve market dominance. The past desire to manage shipment information and achieve visibility over the entire supply chain is now a necessity. Emerging information technologies such as RFID, bar-coding, electronic data interchange, electronic commerce and the Internet are some of the means firms have to compete in an increasingly information-based marketplace.

The Internet provides a host of utilities for gathering and communicating information about a shipment. Some of these utilities are electronic mail, *listservs* (electronic discussion groups) and the WWW. The Internet has even been called the sixth form of transportation.[20] Using the Internet, government and businesses can conduct their operations faster, cheaper and easier than with the more traditional forms of communication—telephone calls, mail and express delivery. Shippers, carriers and customers now have the ability to track the movement of their shipments as well as know the exact contents of a box or container.

Use of the Internet and IT applications has exploded in the commercial sector for logistics functions—in some cases, information is more important than the shipment itself. Not surprisingly, customers want fast materiel delivery and information on-demand for their shipments. In turn, this makes the use of IT for logistics companies "more strategic and critical than ever."[21]

One of the first companies in the Internet-based shipment-tracking business was Federal Express (FedEx). FedEx launched its Internet web site[22] in November 1994 and connected to millions of potential customers. Then, in 1996, it introduced *interNetShip*℠—the first automated shipping transaction utility available on the Internet.[23] InterNetShip℠ software allows customers to complete electronic airbills, print shipping labels, request courier pickups and e-mail shipment status to other parties.[24]

The DoD should be able to reap the benefits of IT in both reduced inventories and the ability to centralize decision-making. The Internet provides a robust platform for organizations or individuals seeking information, all while being relatively inexpensive.[25] RFID and satellite-tracking are two technologies that are being *web-enabled* (linked to the Internet) to provide managers real-time shipping information. This information, in turn, allows for rapid decision-making when alternatives are needed.

Radio Frequency Identification (RFID)

RFID is one form of IT in use by the DoD. It is the concept of "automatically identifying, categorizing, and locating people and assets over relatively short distances (a few inches to hundreds of feet)."[26]

RFID is one form of IT in use by the DoD. It is the concept of "automatically identifying, categorizing, and locating people and assets over relatively short distances (a few inches to hundreds of feet)."[26] Assets are *tagged* with a *transponder* containing information about the item of interest and depending on the type of tag, various *read* and *write* capabilities are possible. The transponder communicates with an *interrogator* using radio frequency (RF) energy and the interrogators are linked to provide seamless coverage for a given system—or supply chain.

RFID tags are being used on vehicles, trucks and other materiel handling equipment in order to track their location, weigh them or even to debit the owner's account when they pass a *toll booth*. RF technology can also provide drivers with new instructions and priorities on a real-time basis. This, in turn, increases flexibility and responsiveness. Logistics functions and firms are using this IT to reroute shipments while in-transit in order to meet customer needs faster. The ability of the Internet to provide quick, accurate data transmission is increasing the overall efficiency of the entire pipeline because managers are receiving better information for decision making and it allows everyone concerned simultaneous access to the distribution channel.[27] Integration of RFID and satellite technology with the capabilities of the Internet makes it possible to relay extensive shipment information such as location, contents and shipping data (for example, origin, destination and priority).

Information System Descriptions

There are numerous DoD logistics and transportation systems in place to provide information on a requisition. Three of these systems were used in this research—the Global Air Transportation and Execution System (GATES), the Logistics Online Tracking System (LOTS) and the Global

Transportation Network (GTN). GATES provides "oversight of worldwide cargo movement" for the airlift portion of the DTS.[28] LOTS is an online automated information system designed for processing and storing logistics data to provide TAV about DoD and civilian agency requisitions and related data.[29]

GTN[30] is an information database accessible via the Internet. Data in GTN is compiled from literally dozens of different DoD and commercial systems. The USTRANSCOM developed GTN "to provide ITV over air and surface shipments moving between ports of embarkation and debarkation (POEs and PODs)."[31] GTN provides a

> seamless, real-time capability to access—and employ—both classified and unclassified transportation and deployment information.[32]

The system is intended to be the integrated transportation portion of the Global Command and Control System (GCCS). As an illustration of its size and responsiveness, the ITV capability in GTN was launched in August 1997 and has a data warehouse of over 43 gigabytes with 80 percent of the information received from the various systems posted within five minutes of receipt.[33]

Uniform Material Movement and Issue Priority System (UMMIPS)

The DoD, through the Defense Logistics Agency (DLA), uses a system of requisition priorities to establish movement standards for all DoD cargo (see Figure 2). The UMMIPS time standards are "the maximum amount of time that should elapse during any given pipeline segment for items that are in stock."[34] The system recognizes the priorities used by both transportation and supply. UMMIPS serves as the "... system for allocating resources among competing demands. It shall be used during peacetime and war."[35] In May 1998, the Under Secretary of Defense for Acquisition and Technology authorized a new set of UMMIPS time standards as part of the new *DoD Materiel Management Regulation, DoD 4140.1-R*. The new standards decreased the maximum time allowed for movement of a shipment as well as redefined the different airlift areas.

Segment	UMMIPS Time Standard (in days)
APOE Port Hold Time	2.0
Transit Time Between APOE and APOD	1.5
APOD Port Hold Time	1.0
AMC Possession Time	4.5

Figure 2. UMMIPS Time Standards for Transportation Priority 1 (TP1) Shipments [36]

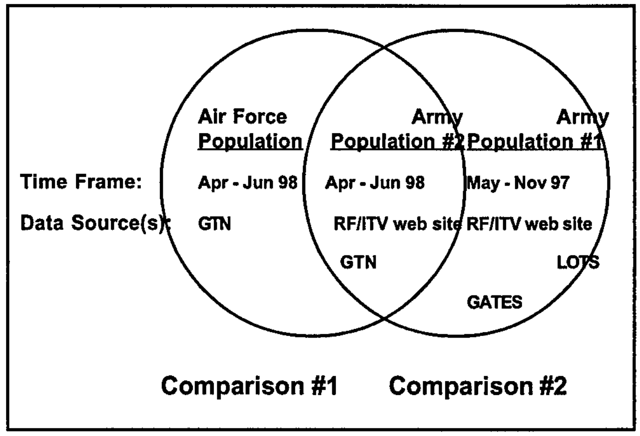

Figure 3. Data Analysis Populations and Information

Methodology

Three sets of data were considered (see Figure 3). All three sets of data considered were shipments originating in the Continental United States (CONUS) with an APOE of Dover AFB, Delaware and an APOD of either Taszar Airfield, Hungary, or Eagle Base, Tuzla, Bosnia. Additionally, all shipments moved through Ramstein AB, Germany, and were in support of OPERATION JOINT ENDEAVOR (OJE) and OPERATION JOINT GUARD (OJG). Thus, routing for all shipments were either Dover-Ramstein-Taszar or Dover-Ramstein-Tuzla.

The primary data consisted of two sets of Army palletized cargo originating from the consolidation/containerization point (CCP) at the Defense Depot, New Cumberland, Pennsylvania. A list of Lead Transportation Control Numbers (TCNs)[37] that were tagged or *burned in* at the New Cumberland depot were retrieved via query from the United States Army Europe (USAREUR) Radio Frequency/In-transit Visibility (RF/ITV) web site.[38] The Lead TCNs collected were matched with relevant transportation pipeline movement data gathered from two sources—the GATES legacy database and the GTN web site.

Transportation movement information for the first population of Army data (Army Population #1) was gathered for high-priority TCNs moving through the AMC portion of the DTS between 9 May 1997 and 29 November 1997. After restricting the initial population to unclassified, non-expedited, non-hazardous, high-priority cargo supporting OJE or OJG, the final population included 189 Lead TCNs.

The second population of Army data (Army Population #2) consisted of high-priority TCNs moving between 1 April 1998 and 26 June 1998. Using the same criteria as for the first population, the second Army sample population resulted in 137 Lead TCNs.

The third (comparative) population was a set of Air Force cargo moving through the same pipeline as both sets of Army cargo. This data set covers the same time period as Army Population #2 (1 April to 26 June 1998). All of the items considered in this population were non-RFID-tagged. The query for Air Force TCNs was conducted using the primary DoD Activity Address Code (DoDAAC)[39] for Taszar (FB5895) and Tuzla (FB5830) and the GTN Cargo Query screen. The final sample population consisted of 90 Air Force TCNs.

The following data elements were required for each sample population:

1. *Transportation Control Number (TCN).*
2. *Aerial Port of Embarkation (APOE).* This is the point of entry into the AMC portion of the DTS. For this research, the APOE is Dover AFB, Delaware.
3. *Aerial Port of Debarkation (APOD).* This is the point of exit from the AMC portion of the DTS. For this research, the APOD is Taszar Airfield, Hungary, or Eagle Base, Tuzla, Bosnia.
4. *Required Delivery Date (RDD) or Transportation Priority (TP).* This is a code that defines the movement priority of a shipment.
5. *APOE Receipt Time.* This is the time the shipment is received at the APOE via motor carrier.
6. *APOE Lift Time.* This is the time the shipment departs the APOE via aircraft.
7. *In-transit Receipt Time.* For this research, this is the time the shipment arrives at Ramstein AB from Dover AFB.
8. *In-transit Lift Time.* For this research, this is the time the shipment departs Ramstein AB for the APOD.
9. *APOD Receipt Time.* This is the time the shipment is received at the APOD.
10. *APOD Lift Time.* This is the time the shipment departs the APOD, usually via motor carrier.

After eliminating outliers, the Large-Sample Test of Hypothesis for two samples was used to compare the means and standard deviations of the different populations.

Four calculations were used for analysis based on their relationship to the UMMIPS time standards:

1. *Port Hold Time (PHT) at the APOE.*
2. *Transit Time Between the APOE and the APOD.*
3. *PHT at the APOD.*
4. *AMC Possession Time* (sum of segments 1, 2 and 3). This calculation reflects the total time a shipment is in the AMC portion of the DTS.

Comparison 1: Air Force Versus Army Population #2

First, Army cargo had a longer average PHT at the APOE than Air Force cargo for both Taszar- and Tuzla-bound shipments. For Taszar-bound shipments, Army cargo was held at the APOE (Dover) more than 2.5 times longer than Air Force cargo (2.77 days versus 1.02 days). For Tuzla-bound shipments, Army cargo was held at the APOE almost twice as long as Air Force cargo (2.32 days versus 1.18 days). Additionally, the standard deviations for Army shipments are at least 50 percent larger than for Air Force shipments (1.50 days versus 0.98 days [Taszar]; 1.46 days versus 0.79 days [Tuzla]).

Second, Army cargo had a longer transit time from APOE to APOD than Air Force cargo for Tuzla-bound shipments. Army shipments took 24 percent longer to transit from the APOE (Dover) to the APOD (Tuzla) than Air Force shipments to the same destination (2.55 days versus 2.06 days). A factor of interest is that the standard deviation for the Army shipments is twice the standard deviation for Air Force shipments (1.37 days versus 0.67 days).

Lastly, Army cargo had a longer AMC Possession Time than Air Force cargo for both Taszar- and Tuzla-bound shipments. For both destinations, the possession time for Army cargo was 28 percent longer than Air Force cargo (5.11 days versus 3.98 days; 6.27 days versus 4.90 days). Furthermore, the standard deviation for Army shipments bound for Taszar is 35 percent larger than for Air Force shipments (1.91 days versus 1.41 days), and the difference for Tuzla-bound shipments is 88 percent larger (2.44 days versus 1.30 days).

Comparison 2: Army Population #2 versus Army Population #1

The results of the test between the two Army populations indicate there is only one statistically significant difference between the two populations in terms of the Port Hold Time at the APOD for Taszar-bound shipments.

An examination of the means and standard deviations of the compared populations reveals that Army Population #1 cargo had an average PHT at the APOD more than five times that of Army Population #2 cargo for Taszar-bound shipments (0.80 days versus 0.14 days). Although test results indicate this is a significant difference, both means are less than one day and unlikely to be significant to the end-user. However, the difference in the range of PHT data for the Army #1 Population runs from 0.0 days to 8.21 days—with only four observations greater than 2.88 days—whereas the range of Army #2 Population data is 0.0 days to 0.92 days. This may indicate the existence of outliers not eliminated[40] or a reflection of events at the APOD.

Comparison 3: Application of UMMIPS Time Standards

Because the primary comparison of interest is the difference between RFID-tagged and non-RFID-tagged shipments, this discussion will focus on the Air Force and Army #2 Populations. Several observations may be made about the results:

1. *PHT at APOE.* Air Force shipments met the UMMIPS time standards almost twice as often as Army shipments for both Taszar- and Tuzla-bound cargo (92.9 percent versus 43.2 percent and 85.3 percent versus 48.4 percent, respectively).
2. *PHT at APOD.* Army shipments met the standards more often than Air Force shipments for both destinations (100.0 percent versus 92.9 percent [Taszar]; 47.3 percent versus 14.7 percent [Tuzla]). This is the only pipeline segment where RFID-tagged shipments moved faster than non-RFID-tagged shipments for both destinations of cargo.
3. *AMC Possession Time.* Air Force shipments met the standards almost twice as often as Army shipments for Taszar-bound cargo (71.4 percent versus 38.6 percent) and more than 1.5 times for Tuzla-bound cargo (29.4 percent versus 18.7 percent).
4. Throughout the pipeline, *Taszar-bound Army shipments* met the UMMIPS time standards approximately 40 percent of the time, but at the APOD (Taszar), 100 percent of the shipments met the standard.
5. *Air Force Taszar-bound shipments* met the UMMIPS time standards for PHT at the APOE and APOD 92.9 percent of the time, yet only 14.3 percent of shipments met the standard for transit time between the APOE and APOD. Additionally, only 71.4 percent of shipments met the standards for AMC Possession Time.
6. *Tuzla-bound Army shipments* met the UMMIPS time

standard for AMC Possession Time less than 20 percent of the time and never exceeded 48.4 percent in the other three segments.

7. *Tuzla-bound Air Force shipments* managed to meet the standard for PHT at APOE 85.3 percent of the time, yet fell below 40 percent for all other pipeline segments. Also, only 14.7 percent met the standard for PHT at APOD (Tuzla).

Findings

Since the primary comparison of interest is between RFID-tagged and non-RFID-tagged shipments, this discussion will focus on the comparison between the Air Force and Army #2 Populations. This research attempted to answer four questions.

Research Question One

Do shipments tagged with RFID technology and reported directly to a WWW accessible database have an average transit time between the Aerial Port of Embarkation (APOE) and the Aerial Port of Debarkation (APOD) below the average transit time of items not tagged?

For Taszar-bound shipments, there was no reason (no statistically significant difference) to conclude that non-RFID-tagged (Air Force) shipments had a different average transit time between APOE and APOD than RFID-tagged (Army Population #2) shipments.

For Tuzla-bound shipments, there was a significant difference between the means of the two populations at the 0.01 alpha-level of significance. RFID-tagged (Army Population #2) shipments had a *longer* average transit time between the APOE and APOD than non-RFID-tagged (Air Force) shipments (2.55 days versus 2.06 days). However, the results of the two-sample t-test show the test statistic, -2.68, is barely outside the range created by the critical value, ±2.62.

Research Question Two

On average, do RFID-tagged shipments have a smaller average Port Hold Time (PHT) than non-tagged shipments?

For the APOE, RFID-tagged (Army) shipments had a significantly *longer* average PHT (2.77 days for Taszar cargo and 2.32 days for Tuzla cargo) at the Dover APOE than non-RFID-tagged (Air Force) shipments (1.02 days for Taszar cargo and 1.18 days for Tuzla cargo).

A potential reason for this difference may lie in the characteristics of the shipments used in this analysis. Air Force shipments, in general, arrive at the Dover APOE unpalletized whereas Army shipments are consolidated (palletized) at a consolidation/containerization point (CCP) before arriving at the Dover AFB aerial port. One of the last steps made by an aircraft loadplanner in planning a load is the addition of any available (processed) small pieces of cargo for the scheduled destination. In this case, small pieces of cargo (for example, 1-cube, 5-pound boxes) are added to a mission more readily than an entire pallet (of any type of cargo).

A second possibility for the longer average PHT of Army cargo is the arrival rate and quantity of the pallets at the APOE. If pallets arrive with insufficient time to be processed and loaded, they *would not* be selected for an outbound aircraft load and may end up waiting until the next day for movement. Likewise, if large quantities of palletized, RFID-tagged cargo arrive at the APOE at the same time, it could take several airlift missions over several days to clear the backlog of cargo. However, since movement priority is first-in, first-out by transportation priority, this reasoning may not add to the explanation of why the Air Force cargo studied had significantly less PHT unless available airlift is scarce. A third possible explanation is the ability of shipping services to *space-block* or reserve space on channel missions. Any one or all of the above possibilities may explain the differences seen in PHT between the RFID-tagged (Army) and non-RFID-tagged (Air Force) cargo as observed in this study.

For both APODs, there was no reason (no statistically significant difference) to conclude that non-RFID-tagged (Air Force) shipments had a different average PHT than RFID-tagged (Army Population #2) shipments. The average PHT for Army shipments arriving at Taszar was 0.15 days whereas Air Force shipments were held an average of 0.29 days. At Tuzla, Army shipments averaged 1.40 days PHT and Air Force shipments averaged 1.67 days. It is interesting, however, that the PHT for Tuzla is so much larger than the PHT at Taszar.

Research Question Three

On average, do RFID-tagged shipments have a smaller AMC Possession Time (total time between receipt at the APOE and departure from the APOD) than non-tagged shipments?

Test results indicated—for both Taszar- and Tuzla-bound shipments—that RFID-tagged (Army) shipments had a *longer* average AMC Possession Time than non-RFID-tagged (Air Force) shipments. Army shipments destined for Taszar had an average AMC Possession Time of 5.11 days and Air Force shipments averaged 3.98 days. Tuzla-bound shipments averaged 6.27 days for Army shipments and 4.90 days for Air Force shipments. Thus, it took more than one day longer for the RFID-tagged (Army) shipments to move through the system than non-RFID-tagged (Air Force) shipments for both cargo destinations. Because there was no significant difference between the two populations for either the transit time between the APOE and APOD or the PHT at the APOD, the most likely (and obvious) reason for the difference in AMC Possession Time is the PHT at the APOE as discussed in Research Question Two.

Research Question Four

On average, are RFID-tagged shipments more likely to meet Uniform Material Movement and Issue Priority System (UMMIPS) time standards than non-tagged shipments?

In terms of AMC Possession Time, non-RFID-tagged (Air Force) shipments met the UMMIPS time standard (of 4.5 days) more often than RFID-tagged (Army) cargo. As noted previously, non-RFID-tagged (Air Force) Taszar-bound shipments met the standard 71.4 percent of the time and Tuzla-bound shipments met the standard 29.4 percent of the time. Although all shipment types performed poorly, RFID-tagged (Army) shipments only met the standard 38.6 percent of the time for Taszar-bound shipments and 18.7 percent of the time for Tuzla-bound shipments.

The pipeline segment contributing the most to this difference is PHT at the APOE. Despite being palletized and ready for onward movement upon arrival at the aerial port, RFID-tagged (Army) shipments only met the UMMIPS time standard (of two days) 43.2 percent of the time for Taszar-bound and 48.4 percent of the time for Tuzla-bound cargo. In contrast, non-RFID-tagged (Air Force) shipments met the standard 92.9 percent of the time for Taszar-bound and 85.3 percent of the time for Tuzla-bound cargo. A possible explanation was discussed previously in Research Question Two.

An examination of PHT at the APOD may provide a partial explanation for the significantly lower percent of Tuzla-bound shipments meeting total AMC Possession Time UMMIPS standards. At Taszar, significant percentages of both tagged and non-tagged shipments met the UMMIPS standard for PHT at the APOD (100.0 percent and 92.9 percent respectively) whereas at Tuzla only 47.3 percent of RFID-tagged and a mere 14.7 percent of non-RFID-tagged cargo met the standard. Although the reason for this difference in PHT between these two locations is unknown, it provides some explanation for the lengthy AMC possession time and the inability to meet the UMMIPS time standard.

There is a perception within the DoD that ITV—in the form of Radio Frequency Identification (RFID) technology—will improve transit time through the Air Mobility Command (AMC) portion of the Defense Transportation System (DTS). The results of this research reject this notion.

Conclusion

There is a perception within the DoD that ITV—in the form of Radio Frequency Identification (RFID) technology—will improve transit time through the Air Mobility Command (AMC) portion of the Defense Transportation System (DTS). The results of this research reject this notion. The research results point strongly to the conclusion that RFID-tagged shipments move *slower* than non-RFID-tagged shipments.

First, there are differences in terms of PHT at the APOE. RFID-tagged shipments waited 2 to 2.5 times longer than non-RFID-tagged shipments at the APOE and the variability of the PHT for RFID-tagged shipments was 1.5 to 2 times greater than for non-RFID-tagged shipments. Second, shipments of RFID-tagged cargo destined for Tuzla had a 24 percent longer average transit time between the APOE and APOD than non-RFID-tagged cargo and had 2 times greater variability. Since tagged and non-tagged cargo travel on the same aircraft together and transit time between locations is stable over time, it would be reasonable to attribute this variability to the Port Hold Time at Ramstein AB. Finally, in terms of total average AMC Possession Time, RFID-tagged shipments were in the AMC system 28 percent longer than non-RFID-tagged shipments and also possessed a larger variability.

Ultimately, the RFID technology described throughout this research is intended to aid the end-user; it was not intended to benefit the different transportation nodes. The original purpose behind the implementation of this technology was to enable the requisitioning unit to know where their supplies are and when to expect them; it was not intended to decrease cycle time.

Notes

1. Department of Defense (DoD), *Defense Intransit Visibility Integration Plan.* Washington, DC: GPO, Feb 95.
2. The Defense Transportation System (DTS) is the part of the national transportation infrastructure supporting DoD transportation needs in peace and war. It consists of "those common-user military and commercial assets, services, and systems organic to, contracted by, or controlled by the DoD." *See:* Department of Defense (DoD), *Military Standard Transportation and Movement Procedures (MILSTAMP), DoD 4500.32-R, Vol. I.* Washington, DC: DoD, 15 Mar 87.
3. AMC functions as the DoD's primary source of cargo airlift. The AMC system is set up on a hub-and-spoke concept. Airlift of cargo and passengers occurs via a series of regularly scheduled (frequency channel) missions or on an *as needed* (requirements channel) basis. AMC's airlift hub system consists of several aerial ports (an airfield selected for the air movement and transshipment of personnel and materiel) linked by these channel missions to collect cargo from spoke locations and forward it to the end-user. AMC's five major aerial ports in the Continental United States (CONUS) are at Charleston AFB, South Carolina; Dover AFB, Delaware; McChord AFB, Washington; McGuire AFB, New Jersey; and Travis AFB, California.
4. *Defense Intransit Visibility Integration Plan*, B-1.
5. *Ibid.*, iii.
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10. Operation Joint Endeavor (OJE) consisted of North Atlantic Treaty Organization (NATO) multinational forces operating in the Bosnia-Herzegovina theater of operations to implement the military aspects of the Bosnia Peace Agreement signed in Dayton, Ohio, on 14 Dec 95 and occurred between 20 Dec 95 and 20 Dec 96. OJG consists of operations as a stabilization force supporting the Dayton Peace Accords from 21 Dec 96 to the present. *See:* North Atlantic Treaty Organization (NATO). "The NATO-led Stabilisation Force (SFOR) in Bosnia and Herzegovina," n. pag. (Apr 97), [Online], Available: http://www.nato.int/docu/facts/sfor.htm, (23 Jul 98).
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37. A Transportation Control Number (TCN) is a unique 17-position alphanumeric data element assigned to control a shipment unit throughout the transportation pipeline. A Lead TCN represents a set of individual shipment TCNs consolidated—physically and systemically—under a single TCN for ease of movement and ITV throughout the DTS.
38. The RF/ITV query screen is located at http://144.170.190.8/ITV_summary.html
39. A DoDAAC is a six position alphanumeric code identifying specific activities authorized to ship or receive materiel and prepare documentation or billings (DoD, 1987: A-4).
40. Shipments were removed from the sample population for only two reasons: the time sequence of events was out of order or the transit time for a particular mission leg fell outside the selected range. Thus, shipments were not eliminated as outliers based on Port Hold Time (PHT).

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